(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 953 597 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.11.1999 Bulletin 1999/44

(51) Int. Cl.[6]: C08K 5/37, C08L 51/06, C08K 5/13

(21) Application number: 99108021.9

(22) Date of filing: 23.04.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 29.04.1998 US 69622

(71) Applicant:
Montell North America Inc.
Wilmington Delaware 19850-5439 (US)

(72) Inventors:
- Schneckenburger, Daniel E.
Elkton, Maryland 21922 (US)
- Berta, Dominic A.
Newark, Delaware 19713 (US)

(74) Representative:
Gaverini, Gaetano et al
Montell Italia S.p.A.
Intellectual Property,
Patents and Trademarks
Via Pergolesi 25
20124 Milano (IT)

(54) Improving heat aging of grafted polyolefins using zinc mercapto compounds

(57) A combination of about 0.5% to about 5% of a zinc salt of 2-mercaptobenzimidazole, 2-mercaptotoluimidazole or 2-mercaptobenzothiazole and about 0.05% to about 0.5% of a hindered phenol compound, based on the total weight of the composition, is used to improve heat aging of graft copolymers having a backbone of a propylene polymer material and side chains of polymerized styrenic and/or acrylic monomers.

EP 0 953 597 A2

Description

Field of the Invention

[0001] This invention relates to the heat stabilization of graft copolymers of propylene polymer materials.

Background of the Invention

[0002] Polyolefins are typically used in products where long term performance is desired or required and where these products are subjected to elevated temperatures that accelerate the rate of oxidative degradation in the polyolefin composition, commonly referred to as "heat aging". Thus it is essential that polyolefins retain their original properties, such as elongation and tensile strength, at elevated temperatures during the desired term of performance.

[0003] It is known that zinc salts of mercapto compounds such as 2-mercaptobenzothiazole, 2-mereaptotoluimidazole, and 2-mercaptohenzimidazole, are usefil for improving the heat aging of thermoplastic elastomers as disclosed in U.S. Patent 5,196,462. The zinc mercapto compounds can also be used in combination with sterically hindered phenol compounds in thermoplastic elastomers as disclosed in U.S. Patent 5,158,997.

[0004] Zinc salts of mercapto compounds have also been used in flame- and smoke-retardant compositions for various polymers. For example, zinc salts of 2-mercaptobenzothiazole, benzoxazole, and benzimidazole have been used in polystyrene as a smoke retardant on burning as disclosed in U.S. 4,011,194. U.S. 4,857,673 discloses the use of a combination of a hindered phenol and a zinc salt of mercaptobenzimidazole or mercaptotolylimidazole in a flame retardant insulating composition that also contains an antimony compound, a lead compound, a peroxide curing agent and an ethylene homopolymer or copolymer, or blends of these ethylene polymers with other polymers.

[0005] Heat aging is also a problem with graft copolymers of polypropylene. However, the mechanism for the degradation of polystyrene and other polymerized monomers that are grafted onto the polypropylene backbone is somewhat different than that of polyolefins, and the grafted polymers would be expected to degrade independently of the polyolefln backbone, e.g., the thermooxidative stability of unmodified polystyrene is relatively high, while polypropylene is very sensitive to oxidation and cannot be used without adequate stabilization. Thus there is still a need for additives that will improve heat aging of propylene polymer materials, to which various monomers have been graft polymerized.

Summary of the Invention

[0006] The composition of this invention comprises:

(1) a graft copolymer comprising a backbone of a propylene polymer material having graft polymerized thereto polymerized monomers selected from the group consisting of

- (a) vinyl-substituted aromatic compounds,
- (b) unsaturated aliphatic acids or esters thereof,
- (c) anhydrides of unsaturated aliphatic dicarboxylic acids, and
- (d) mixtures thereof;

(2) about 0.05% to about 0.5% by weight of a sterically hindered phenol compound, based on the total weight of the composition; and

(3) about 0.5% to about 5.0% by weight of zinc 2-mercaptobenzothiazole, zinc 2-mercaptotoluimidazole or zinc 2-mercaptobenzimidazole, based on the total weight of the composition.

Compositions containing a mineral filler or glass fibers have also been prepared. Graft copolymers containing a combination of a hindered phenol and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

Detailed Description of the Invention

[0007] The propylene polymer that is used as the backbone of the graft copolymer of this invention can be

(a) a crystalline homopolymer of propylene having an isotactic index greater than 80, preferably about 85 to about 99;

(b) a crystalline copolymer of propylene and an olefin selected from the group consisting of ethylene and C_4-C_{10} α-olefins, provided that when the olefin is ethylene, the maximum polymerized ethylene content is 10% by weight,

preferably about 4%, and when the olefin is a C_4-C_{10} α-olefin, the maximum polymerized content thereof is 20% by weight, preferably about 16%, the copolymer having an isotactic index greater than 85;

(c) a crystalline terpolymer of propylen and two olefins selected from the group consisting of ethylene and C_4-C_8 α-olefins, provided that the maximum polymerized C_4-C_8 α-olefin content is 20% by weight, preferably about 16%, and, when ethylene is one of the olefins, the maximum polymerized ethylene content is 5% by weight, preferably about 4%, the terpolymer having an isotactic index greater than 85;

(d) an olefin polymer composition comprising:

(i) about 10% to about 50% by weight, preferably about 10% to about 40%, and most preferably about 20% to about 35%, of a propylene homopolymer having an isotactic index of about 80% to about 99%, and preferably about 85% to about 99%, or a copolymer selected from the group consisting of (a) a copolymer of propylene and ethylene, (b) propylene, ethylene and a CH_2=CHR alpha-olefin, where R is a 2-8 C straight or branched alkyl group, and (c) propylene and an alpha-olefin as defined above in (i)(b), wherein the copolymer contains about 85% to about 99%, and preferably about 90% to about 99% propylene and has an isotactic index greater than 80% to about 98%, preferably greater than 85% to about 98%,

(ii) about 3% to about 20%, preferably about 7% to about 15%, of a semi-crystalline, essentially linear copolymer having a crystallinity of about 20% to about 60% by differential scanning calorimetry (DSC), wherein the copolymer is selected from the group consisting of (a) ethylene and propylene containing over 50% ethylene; (b) ethylene, propylene, and an alpha-olefin as defined above in (i)(b), containing about 1% to about 10% of the alpha-olefin and over 50% up to 98%, preferably about 80% to about 95%, of both ethylene and alpha-olefin; and (c) ethylene and an alpha-olefin as defined in (i)(b), containing over 50% up to 98%, preferably about 80% to about 95%, of the alpha-olefin, which copolymer is insoluble in xylene at room or ambient temperature, and

(iii) about 40% to about 80%, preferably about 50% to about 70%, of a copolymer selected from the group consisting of a copolymer of (a) ethylene and propylene wherein the copolymer contains from 20% to less than 40%, preferably from 20% to about 38%, most preferably about 25% to about 38% ethylene, (b) ethylene, propylene, and an alpha-olefin as defined in (i)(b), wherein the alpha-olefin is present in an amount of about 1% to about 10%, preferably about 1% to about 5%, and the amount of ethylene and alpha-olefin present is from 20% to less than 40%, and (c) ethylene and an alpha-olefin as defined in (i)(b), containing from 20% to less than 40%, preferably from 20% to about 38%, and most preferably about 25% to about 38% of the alpha-olefin, and optionally containing about 0.5% to about 10%, preferably about 1% to about 5% of a diene, the copolymer (iii) being soluble in xylene at ambient temperature, and having an intrinsic viscosity of about 1.5 to about 4.0 dl/g, preferably about 1.7 to about 3.0 dl/g, wherein the total amount of ethylene units or the alpha-olefin units in the olefin polymer composition or of ethylene and the alpha-olefin units when both are present in the olefin polymer composition is about 15% to about 35%,

wherein the total amount of (ii) and (iii), based on the total olefin polymer composition is about 65% to about 80%; the weight ratio of (ii)/(iii) is less than 0.4, preferably about 0.1 to about 0.3; the total content of ethylene or 4-8 C alpha-olefin or combination thereof in (ii) + (iii) is less than 50%, and preferably about 20% to about 45%, and the composition is prepared by polymerization in at least two stages and has a flexural modulus of less than 150 MPa; or

(e) a thermoplastic olefin comprising:

(i) about 10% to about 60%, preferably about 20% to about 50%, of a crystalline propylene homopolymer having an isotactic index greater than 80, or a crystalline copolymer selected from the group consisting of (a) a copolymer of ethylene and propylene, (b) a terpolymer of ethylene, propylene, and a C_4-C_8 α -olefin, and (c) a copolymer of ethylene and a C_4-C_8 α-olefin, the copolymer having a propylene content greater than 85% and an isotactic index of greater than 85;

(ii) about 20% to about 60%, preferably about 30% to about 50%, of an amorphous copolymer selected from the group consisting of (a) a copolymer of ethylene and propylene, (b) a terpolymer of ethylene, propylene, and a C_4-C_8 α-olefin, and (c) a copolymer of ethylene and a C_4-C_8 α-olefin, the copolymer optionally containing about 0.5% to about 10% of a diene and containing less than 70% ethylene and being soluble in xylene at ambient temperature; and

(iii) about 3% to about 40%, preferably about 10% to about 20%, of a copolymer of ethylene and propylene or a C_4-C_8 α-olefin that is insoluble in xylene at ambient temperature,

wherein the composition has a flexural modulus of greater than 150 but less than 1200 MPa, preferably about 200 to about 1100 MPa, most preferably about 200 to about 1000 MPa.

[0008] Room or ambient temperature is ~ 25°C.

[0009] C_{4-8} α-olefins useful in the preparation of (d) and (e) include, for example, butene-1; pentene-1 ;hexene-1; 4-methyl-1 -pentene, and octene-1.

[0010] The diene, when present, is typically a butadiene; 1,4-hexadiene; 1,5-hexadiene, or ethylidenenorbornene.

[0011] The preparation of propylene polymer material (d) is described in more detail in U.S. Patents 5,212,246 and 5,409,992, the disclosures of which are incorporated herein by reference. The preparation of propylene polymer material (e) is described in more detail in U.S. Patents 5,302,454 and 5,409,992, the disclosures of which are incorporated herein by reference.

[0012] Propylene homopolymer is the preferred propylene polymer backbone material.

[0013] The monomers that form grafted polymers or copolymers on the backbone of propylene polymer material are selected from the group consisting of (a) vinyl-substituted aromatic compounds, such as, for example, styrene, alpha- and para-methylstyrene, and p-t-butylstyrene, (b) unsaturated aliphatic carboxylic acids and esters thereof, such as, for example, acrylic acid; methacrylic acid; acrylate esters such as methyl, ethyl, hydroxyethyl, 2-ethylhexyl, and butyl acrylate esters; and methacrylate esters such as the methyl, ethyl, butyl, benzyl, phenylethyl, phenoxyethyl, epoxypropyl, and hydroxypropyl methacrylate esters, (c) anhydrides of aliphatic unsaturated dicarboxylic acids, such as, for example, maleic anhydride, and (d) mixtures thereof. Preferred monomers include styrene, methyl methacrylate-co-methyl acrylate, and styrene-co-α-methylstyrene-co-maleic anhydride.

[0014] The monomers are added in an amount of about 5 to about 240 parts per hundred parts of the propylene polymer material, preferably about 20 parts to about 100 pph.

[0015] During the graft polymerization, the monomers also polymerize to form a certain amount of free or ungrafted polymer or copolymer. The morphology of the graft copolymer is such that the propylene polymer material is the continuous or matrix phase, and the polystyrene or other polymerized monomers, both grafted and ungrafted, are a dispersed phase.

[0016] The graft copolymer can be made according to any one of various methods. One of these methods involves forming active grafting sites on the propylene polymer material either in the presence of the grafting monomers, or followed by treatment with the monomers. The grafting sites can be produced by treatment with a peroxide or other chemical compound that is a free radical polymerization initiator, or by irradiation with high energy ionizing radiation. The free radicals produced in the polymer as a result of the chemical or irradiation treatment form the active grafting sites on the polymer and initiate the polymerization of the monomers at these sites. Graft copolymers produced by peroxide-initiated grafting methods are preferred.

[0017] Preparation of graft copolymers by contacting the propylene polymer with a free radical polymerization initiator such as an organic peroxide and a vinyl monomer is described in more detail in U.S. Patent 5,140,074, the disclosure of which is incorporated herein by reference. Preparation of graft copolymers by irradiating an olefin polymer and then treating with a vinyl monomer is described in more detail in U.S. Patent 5,411,994, the disclosure of which is incorporated herein by reference.

[0018] Heat aging of the graft copolymers of this invention is improved by using a combination of about 0.5% to about 5.0%, preferably about 1.2% to about 1.6%, based on the total weight of the composition, of zinc 2-mercaptobenzimidazole, zinc 2-mercaptotoluimidazole or zinc 2-mercaptobenzothiazole, and about 0.05% to about 0.5%, preferably about 0.15% to about 0.20%, based on the total weight of the composition, of a sterically hindered phenol compound.

[0019] Sterically hindered phenol compounds suitable for use in the present invention include, for example, 2,6-di-t-butyl-p-cresol; octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl) propionate; N, N'-hexamethylene bis(3,5-di-t-butyl-4-hydroxy-hydrocinnamate); hexamethylene bis(3,5-di-t-butyl-4-hydroxyhydrocinnamate), and tetrakis[methylene(3',5'-di-t-butyl-4-hydroxy-hydrocinnamate]methane.

[0020] Optionally, the composition can also contain about 2% to about 30%, preferably about 5% to about 15%, based on the total weight of the composition, of one or more rubber components, and about 5% to about 90%, preferably about 10% to about 70%, based on the total weight of the composition, of a broad molecular weight distribution propylene polymer material.

[0021] The rubber component is selected from one or more of the group consisting of (i) an olefin copolymer rubber, (ii) a monoalkenyl aromatic hydrocarbon-conjugated diene block copolymer, and (iii) a core-shell rubber. Any of these rubber components can have acid or anhydride functionality or can be free of these functional groups. The preferred rubber components are (i) or (ii), either alone or in combination.

[0022] Suitable olefin copolymer rubbers include, for example, saturated olefin copolymer rubbers such as ethylene/propylene monomer rubbers (EPM), ethylene/octene-1, and ethylene/butene-1 rubbers, and unsaturated olefin copolymer rubbers such as ethylene/propylene/diene monomer rubbers (EPDM). The preferred olefin copolymer rubbers are ethylene/propylene, ethylene/butene-1, and ethylene/octene-1 copolymers.

[0023] The monoalkenyl aromatic hydrocarbon-conjugated diene block copolymer can be a thermoplastic elastomer of the A-B (or diblock) structure, the linear A-B-A (or triblock) structure, the radial $(A-B)_n$ type where n = 3-20%, or a combination of these structure types, wherein each A block is a monoalkenyl aromatic hydrocarbon polymer block, and

each B block is an unsaturated rubber block. Various grades of copolymers of this type are commercially available. The grades differ in structure, molecular weight of the mid and end blocks, and ratio of monoalkenyl aromatic hydrocarbon to rubber. The block copolymer can also be hydrogenated. Typical monoalkenyl aromatic hydrocarbon monomers are styrene, ring-substituted C_1-C_4 linear or branched alkyl styrenes, and vinyltoluene. Styrene is preferred. Suitable conjugated dienes include, for example, butadiene and isoprene. Preferred block copolymers are hydrogenated styrene/ethylene-butene-1/styrene triblock copolymers.

[0024] The weight average molecular weight M_w of the block copolymers generally will be in the range of about 45,000 to about 260,000 g/mole, average molecular weights in the range of about 50,000 to about 125,000 g/mole being preferred on the basis that they produce compositions having the best balance of impact strength and stiffness. Also, while block copolymers having unsaturated as well as saturated rubber blocks can be used, copolymers having saturated rubber blocks are preferred, also on the basis of the impact/stiffness balance of the compositions containing them. The weight ratio of monoalkenyl aromatic hydrocarbon to conjugated diene rubber in the block copolymer is in the range of about 5/95 to about 50/50, preferably about 10/90 to about 40/60.

[0025] The core-shell rubber components comprise small particles of a crosslinked rubber phase surrounded by a compatibilizing shell, normally a glassy polymer or copolymer. The core is typically a diene rubber such as butadiene or isoprene rubber, or a polyacrylate. The shell is typically a polymer of two or more monomers selected from styrene, methyl methacrylate, and acrylonitrile. Particularly preferred core-shell rubbers have a polyacrylate core.

[0026] Suitable impact modifiers include, for example, Engage 8150 ethylene/octene-1 copolymer, commercially available from DuPont-Dow Elastomers; EPM 306P ethylene/propylene copolymer, commercially available from the Polysar Rubber Division of Miles, Incorporated; and Kraton RP6912 styrene/ethylene-propylene/styrene triblock copolymer rubber and Kraton FG1901X styrene/ethylene-butene-1/styrene triblock copolymer rubber modified with maleic anhydride, commercially available from Shell Chemical Company.

[0027] Another optional ingredient is a broad molecular weight distribution propylene polymer material (BMWD PP) having a M_w/M_n of about 5 to about 60, preferably about 5 to about 40; a melt flow rate of about 0.5 to about 50, preferably about 1 to about 30 g/10 min, and xylene insolubles at 25°C of greater than or equal to 94%, preferably greater than or equal to 96%, and most preferably greater than or equal to 98%. The propylene polymer material having a broad molecular weight distribution can be a homopolymer of propylene or an ethylene/propylene rubber impact-modified homopolymer of propylene, wherein the propylene homopolymer has a broad molecular weight distribution.

[0028] The BMWD PP can be prepared by sequential polymerization in at least two stages, in the presence of a Ziegler-Natta catalyst supported on magnesium halide in active form. The polymerization process occurs in separate and consecutive stages, and in each stage polymerization takes place in the presence of the polymer and the catalyst from the preceding stage.

[0029] The polymerization process can be carried out in a batch or in a continuous mode according to known techniques, operating in liquid phase in the presence or not of an inert diluent, or in gas phase, or liquid-gas phase, preferably in gas phase. The preparation of the BMWD PP is described in more detail in U.S. Patent 5,286,791, which preparation is incorporated herein by reference.

[0030] The composition of this invention can also contain an inorganic filler such as $CaCO_3$ or talc. The filler is present in an amount of about 20% to about 35%, preferably about 30% to about 35%.

[0031] Glass fibers can also be added as a reinforcing agent. When present, they are used in an amount of about 20% to about 50%, preferably about 30% to about 40%, based on the total weight of the composition. A compatibilizing agent such as maleic anhydride-modified polypropylene is generally used with glass fibers. Polypropylenes modified with various amount of maleic anhydride are available commercially, for example, from Eastman Chemical Company and Aristech Chemicals. The compatibilizing agent is used in an amount of about 1% to about 3%, based on the total weight of the composition.

[0032] Other additives such as pigments, slip agents, waxes, oils, antiblocking agents, and antioxidants can also be present in the composition.

[0033] The test methods used to evaluate the molded specimens were:

Tensile strength	ASTM D-638-89
Elongation at yield	ASTM D-638-89
Elongation at break	ASTM D-638-89
Shore D hardness	ASTM D-2240
Melt flow rate, 230°C, 3.8 kg	ASTM D-1238

[0034] The polydispersity index (P.I) is defined as the inverse of the cross-over modulus obtained from a frequency scan as described in G. R. Zeichner and P. D. Patel, "A Comprehensive Evaluation of Polypropylene Melt Rheology", Proc. 2nd World Cong. on Chem. Eng., Vol. 6, p. 333, Montreal, 1981.

[0035] Isotactic index is defined as the xylene insoluble fraction. The weight percent of olefin polymer soluble in xylene

at room temperature is determined by dissolving 2.5 g of the polymer in 250 ml of xylene in a vessel equipped with a stirrer that is heated at 135°C with agitation for 20 minutes. The solution is cooled to 25°C while continuing the agitation, and then left to stand without agitation for 30 minutes so that the solids can settle. The solids are filtered with filter paper, the remaining solution is evaporated by treating it with a nitrogen stream, and the solid residue is vacuum dried at 80°C until a constant weight is reached. The percent by weight of polymer insoluble in xylene at room temperature is the isotactic index of the polymer. The value obtained in this manner corresponds substantially to the isotactic index determined via extraction with boiling n-heptane, which by definition constitutes the isotactic index of the polymer.

[0036] Intrinsic viscosity is measured in tetrahydronaphthalene at 135°C.

[0037] The crystallinity of an ethylene copolymer is measured from the heat of fusion of the copolymer, which is determined by differential scanning calorimetry on a 5 to 10 mg sample of the copolymer heated at 20°C/min and assuming the heat of fusion of 100% crystalline polyethylene at 400°K is 293 J/g as described in U. Gaur and B. Wunderlich, J. Phys. Chem. Ref. Data, 10 (1), 119 (1981). The percent crystallinity is calculated by dividing the heat of fusion of the copolymer by the heat of fusion of 100% crystalline polyethylene and multiplying by 100.

[0038] Molecular weight measurements were made by gel permeation chromatography.

[0039] All heat aging tests were done at 160°C. It should be noted that this is a very severe test for polyolefins and that this temperature is higher than the temperature normally used. In the tables, samples that lost their integrity and could not be tested were marked "FAIL". Typically samples that exhibited less than 50% loss in tensile strength and/or minimal weight loss showed improved heat aging compared with controls that did not contain a combination of a zinc salt of 2-mercaptobenzothiazole or 2-mercaptobenzimidazole and a hindered phenol compound.

[0040] In this specification, all parts and percentages are by weight unless otherwise noted.

Example 1

[0041] This example demonstrates the effect on heat aging when a combination of a zinc salt of a mercapto compound and a hindered phenol is incorporated into a graft copolymer comprising a propylene homopolymer backbone, onto which styrene was graft polymerized (PP-g-S).

[0042] The propylene homopolymer used as the backbone polymer had an average MFR of 20 g/10 min and a poured bulk density of 0.340-0.345 g/cm^3, and is commercially available from Montell USA Inc.

[0043] The monomers were grafted onto the polypropylene backbone at a grafting temperature of 120°C using the previously described peroxide-initiated graft polymerization process. Forty-five parts by weight of styrene were added per 100 parts of polypropylene. Lupersol PMS 50% t-butylperoxy-2-ethyl hexanoate in mineral spirits, commercially available from Elf Atochem, was used as the peroxide initiator. The monomer was fed at 0.9 pph/min, and a monomer to initiator molar ratio of 105 was used. After completion of monomer and peroxide addition, the temperature was raised to 140°C for 60 minutes under a nitrogen purge.

[0044] In Table 1, Irganox B-225 phenolic antioxidant is a blend of 1 part Irganox 1010 tetrakis[methylene(3,5-di-tert-butyl-4-hydroxyhydrocinnamate)]methane stabilizer and 1 part Irgafos 168 tri(2,4-di-t-butylphenyl)phosphite stabilizer, and is commercially available from CIBA Specialty Chemicals Corporation. Some samples contained an additional 0.2 pph of Irganox 1010 antioxidant.

[0045] Zetax zinc salt of 2-mercaptobenzothiazole and ZMTI zinc salt of 2-mercaptobenzimidazole are commercially available from R. T. Vanderbilt Company Incorporated.

[0046] The samples were premixed by tumbling by hand and were then charged to a Haake Rheocord internal mixer using a 250 g mixing head with Banbury mixing blades. The mix chamber had a temperature of 180°C and the rotor speed was 100 rpm. Mixing was continued until fluxing occurred, usually within two minutes, and then continued for about two more minutes.

[0047] The charge from the mixer was divided into four portions and 4" x 4" compression molded plaques were prepared from each portion by pressing with a PHI compression molding press at 215°C. Specimens for testing were die cut using a Carver press. The results of the property evaluations for each sample are given in Table 1.

Table 1

Sample	Control 1	Control 2	1	2	3
PP-g-S(prts.by wt.)	100	100	100	100	100
Irganox 1010 (pph)	-	0.2	0.2	-	0.2
Zetax (pph)	-	-	2	-	-
ZMTI (pph)	-	-	-	2	2
Irganox B225 (pph)	0.2	0.2	0.2	0.2	0.2
Original Properties					
Tensile strength at yield (psi)	3323	3376	3232	3148	3042
Elongation at yield (%)	4	5	4	4	4
Shore D hardness	70	69	70	70	70
Aged at 160°C					
(3 days)					
Tensile strength at yield (psi)	3454	3458	3398	3392	3310
Elongation at yield (%)	3	3	3	3	3
Shore D hardness	72	72	73	71	73
(13 days)					
Tensile strength at yield (psi)	FAIL	3533	3507	3448	3184
Elongation at yield (%)		3	2	3	2
Shore D hardness		71	72	71	72
Weight loss (%)	30	3	0	0	0
(21 days)					
Tensile strength at yield (psi)	FAIL	FAIL	3539	3242	3470
Elongation at yield (%)			2	2	2
Shore D hardness			72	72	73
Weight loss (%)	37	--	0	3	5

[0048] The data show that polypropylene-g-styrene compositions containing a combination of a phenolic antioxidant and the zinc salt of a mercapto compound exhibit improved heat aging compared to samples without the zinc salt. After 21 days the tensile strength was not measurable for either control and the weight loss was 37% for Control 1 and not measurable for Control 2.

Example 2

[0049] This example demonstrates the effect on heat aging when a combination of a hindered phenol compound and a zinc salt of a mercapto compound is incorporated into a glass-reinforced composition containing a graft copolymer comprising a propylene homopolymer backbone, onto which styrene was graft polymerized.

[0050] The propylene homopolymer used as the backbone polymer was the same as in Example 1.

[0051] The graft copolymer was prepared as described in Example 1, except that 85 parts of styrene were added per

hundred parts of polypropylene and the monomer feed rate was 1 pph/min.

[0052] The stabilizer package used was 0.07 wt. % calcium stearate, 0.175 wt. % Irganox 1010 phenolic antioxidant or Irganox B-225 phenolic antioxidant, and 1.39 wt. % of either Zetax zinc salt of 2-mercaptobenzothiazole or ZMTI zinc salt of 2-mercaptobenzimidazole, all percentages being by weight, based on the total weight of the composition.

[0053] PPG 3232 Glass fibers, 10-14 μm in diameter with a chopped strand size of 0.125 - 0.1875" and sized with an aminosilane sizing agent, were added in an amount of 30 wt. %. The glass fibers are commercially available from PPG Industries Inc. A maleic anhydride-grafted polypropylene having a maleic anhydride content of 1.4% was added as a compatibilizer in an amount of 1.39 wt. %.

[0054] The samples were compounded on a 40 mm ZSK extruder at a barrel temperature of 230°C, a screw speed of 425 rpm and a throughput rate of 210 lb/hr. One inch x 1/8" test bars were used for all of the physical property measurements. Test bars were produced on a 5 oz Battenfeld injection molding machine at a barrel temperature of 475°F and a mold temperature of 125°F. The results of the property evaluations are given in Table 2.

Table 2

Sample	Control 1	Control 2	1	2	3
PP-g-S (%)	68.36	68.37	66.975	66.975	66.975
Compatibilizer (%)	1.4	1.39	1.39	1.39	1.39
Glass fibers (%)	30	30	30	30	30
Irganox B225 (%)	0.175	-	-	-	0.175
Irganox 1010 (%)	-	0.175	0.175	0.175	-
Zetax (%)	-	-	1.39	-	-
ZMTI (%)	-	-	-	1.39	1.39
Calcium stearate (%)	0.07	0.07	0.07	0.07	0.07
Physical Properties					
0 Hour Control					
Tensile strength (psi)	14260	13560	13260	15210	14240
Elongation at break (%)	9.22	6.3	8.683	8.837	8.243
Weight (g)	0.86		0.87	0.87	0.87
5 Day Aging 160°C					
Tensile strength (psi)	2968	11050	12010	10890	11660
Retained strength (%)	20.81	81.48	90.57	71.59	81.88
Elongation at break (%)	1.7	2.94	6.483	6.108	6.918
Retained elongation (%)	-	46.7	74.66	69.11	83.92
Weight loss (%)	2.5		0	0	0
10 Day Aging 160°C	FAIL				
Tensile strength (psi)		4250	7902	10900	8691
Retained strength (%)		31.3	59.59	71.66	61.03
Elongation at break (%)		1.06	4.439	6.491	4.814
Retained elongation (%)		16.8	51.12	73.45	58.4
Weight loss (%)		-	0	0	0
20 Day Aging 160°C		FAIL			
Tensile strength (psi)			6356	9429	6655
Retained strength (%)			47.9	61.9	46.73
Elongation at break (%)			1.208	1.789	1.275
Retained elongation (%)			13.91	20.24	15.46
Weight loss (%)			0.68	1.03	1.49
30 Day Aging 160°C					
Tensile strength (psi)			4712	7252	3596
Retained strength (%)			35.53	47.68	25.25
Elongation at break (%)			-	1.018	0.8975
Retained elongation (%)			-	11.51	10.88
Weight loss (%)			1.68	1.65	2.44

[0055] The data show that glass-reinforced polypropylene-g-styrene compositions containing a combination of a hindered phenol compound and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

Example 3

[0056] This example demonstrates the effect on heat aging of incorporating a combination of a hindered phenol compound and a zinc salt of a mercapto compound into impact-modified, glass-reinforced formulations containing a graft copolymer comprising a backbone of propylene homopolymer, onto which styrene was graft polymerized.
[0057] The propylene homopolymer used as the backbone polymer was the same as in Example 1.
[0058] The graft copolymer was prepared as described in Example 1.
[0059] The graft copolymer was then blended with a broad molecular weight distribution polypropylene (BMWD PP1) having a polydispersity index (PI) of 7-12 and a melt flow rate (MFR) of 12.0 g/10 min, which is commercially available from Montell USA Inc. The amount of BMWD PP added to each sample is given in Table 3.
[0060] The stabilizer package used was 0.07 wt. % calcium stearate, 0.175% Irganox 1010 antioxidant, and 1.4% of either Zetax zinc 2-mercaptobenzothiazole or ZMTI zinc 2-mercaptobenzimidazole, all percentages being by weight, based on the total weight of the composition.
[0061] In Table 3, the glass fiber and the compatibilizer were the same as in Example 2. Kraton RP6912 styrene/ethylene-propylene/styrene triblock copolymer containing 29% styrene and 71% ethylene-propylene and Kraton FG1901X styrene/ethylene-butene-1/styrene triblock copolymer containing 1% grafted maleic annydride are commercially available from Shell Chemical Company. EPM 306P random ethylene/propylene copolymer having an ethylene content of 57% is commercially available from Polysar Rubber Division of Miles, Incorporated.
[0062] The samples were compounded and extruded on a 40 mm ZSK extruder at a barrel temperature of 240°C, a screw speed of 450 rpm, and a throughput rate of 200 lb/hr. The compounded samples were molded into test bars as described in Example 2. The results of the property evaluations are given in Table 3.

Table 3			
Sample	**Control**	**1**	**2**
BMWD PP 1 (%)	22.04	21.337	21.337
PP-g-S (%)	22.04	21.338	21.338
Compatibilizer (%)	1.3	1.3	1.3
Glass fibers (%)	35	35	35
Kraton RP6912 (%)	6.46	6.46	6.46
Kraton FG1901X (%)	6.46	6.46	6.46
Polysar EPM 306P (%)	6.46	6.46	6.46
Irganox 1010 (%)	0.175	0.175	0.175
Zetax (%)	-	1.4	-
ZMTI (%)	-	-	1.4
Calcium stearate (%)	0.07	0.07	0.07
Physical Properties			
0 Hour Control			
Tensile strength (psi)	11,730	9850	10,510
Elongation @ break (%)	6.09	12.85	13.57
Weight (g)		0.85	0.85
5 Day Aging 160°C			
Tensile strength (psi)	4400	9728	10,480
Retained strength (%)	37.5	98.76	99.7
Elongation @ break (%)	1..3	9.463	13.7
Retained elongation (%)	21.3	73.64	100.9
Weight loss (%)	-	0	0
10 Day Aging 160°C			
Tensile strength (psi)	4799	7784	11,420
Retained strength (%)	40.9	79.02	108.9
Elongation at break (%)	1.15	8.582	13.33
Retained elongation (%)	18.9	66.78	98.2

continuation of table 3

Weight loss (%)	-	0	0
20 Day Aging 160°C	FAIL		
Tensile strength (psi)		6324	8529
Retained strength (%)		64.2	81.15
Elongation at break (%)		1.244	5.226
Retained elongation (%)		9.68	38.51
Weight loss (%)		27.65	1.2
30 Day Aging 160°C		FAIL	
Tensile strength (psi)			6063
Retained strength (%)			57.69
Elongation at break (%)			1.457
Retained elongation (%)			10.74
Weight loss (%)			9.53

[0063] The data show that impact-modified, glass-reinforced polypropylene-g-styrene compositions containing a combination of a hindered phenol compound and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

Example 4

[0064] This example demonstrates the effect on heat aging when a combination of a phenolic antioxidant and a zinc salt of a mercapto compound are incorporated into an impact-modified formulation containing 30% of a calcium carbonate filler and a graft copolymer comprising a propylene homopolymer backbone, onto which styrene was graft polymerized.

[0065] The propylene homopolymer used as the backbone polymer had an average MFR of 9 g/10 min and a poured bulk density of 0.340-0.345 g/cm^3, and is commercially available from Montell USA Inc.

[0066] The graft copolymer was prepared as described in Example 1 except that 85 parts of styrene per hundred parts of polypropylene were added and the monomer feed rate was 1 pph/min.

[0067] The graft copolymer was then blended with either BMWD PP 1, described in Example 3; BMWD PP 2, which had a MFR of 1.0 g/10 min, and a PI of 5.0 - 8.0, or BMWD PP 3, comprising 86% of a BMWD propylene homopolymer matrix and 14% of an ethylene/propylene copolymer with an ethylene content of 50%, all commercially available from Montell USA Inc. 30% Supercoat $CaCO_3$, commercially available from ECC International, was added to all samples.

[0068] In Table 4, Kraton G1652 was a styrene/ethylene-butene-1/styrene triblock copolymer rubber containing 29% styrene and 71% ethylene/butene-1 rubber midblock, commercially available from Shell Chemical Company. EPM 306P rubber was described in Example 3.

[0069] The stabilizer package used was 0.07% calcium stearate, 1.39% of either Zetax zinc 2-mercaptobenzothiazole or ZMTI zinc mercaptobenzimidazole, and 0.175% Irganox 1010 phenolic antioxidant, all percentages being by weight, based on the total weight of the composition.

[0070] The samples were compounded and extruded on a 34 mm Leistritz extruder at a barrel temperature of 200°C, a screw speed of 375 rpm and a throughput rate of 40 lb/hr. The compounded samples were molded into test bars as described in Example 2. The results of the property evaluations are given in Table 4.

Table 4						
Sample	**C ntrol 1**	**Control 2**	1	2	3	4
BMWD PP 1 (%)	52.0	-	50.845	50.845	-	-
PP-g-S (%)	7.26	27.66	7.02	7.02	26.265	26.265
BMWD PP 2 (%)	-	12.0	-	-	12	12
BMWD PP 3 (%)		19.1	-	-	19.1	19.1
$CaCO_3$ (%)	30	30	30	30	30	30
Kraton G1652 (%)	5.25	5.5	5.25	5.25	5.5	5.5
Polysar EPM 306P (%)	5.25	5.5	5.25	5.25	5.5	5.5
Irganox 1010 (%)	0.175	0.175	0.175	0.175	0.175	0.175
Zetax (%)	-	-	1.39	-	1.39	-
ZMTI (%)	-	-	-	1.39	-	1.39
Calcium stearate (%)	0.07	0.07	0.07	0.07	0.07	0.07
Physical Properties						
0 hour Control						
Tensile strength (psi)	3986	3675	3330	3798	3469	3604
Elongation at Break (%)	32.2	19.1	166	410.9	278.6	274.3
Weight (g)	2.394	2.396	0.8	0.82	0.82	0.8
5 Day Aging 160°C						
Tensile strength (psi)	3778	3534	3591	4024	3428	3705
Retained strength (%)	94.8	96.2	107.8	105.9	98.8	102.8
Elongation at break (%)	22.3	15.2	23.38	145	14.97	113.5
Retained elongation (%)	69.3	79.6	14.08	35.28	5.37	41.37
Weight loss (%)	0.8	0.9	0	0	-1.22	-1.25
10 Day Aging 160°C						
Tensile strength (psi)	3876	3660	3670	3750	3622	3654
Retained strength (%)	97.2	99.6	110.2	101.3	104.4	101.4
Elongation at break (%)	16.2	10.3	28.13	78.1	13.17	94.9

continuation of table 4

Retained elongation (%)	50.3	53.9	16.9	19	4.7	34.6
Weight loss (%)	10.5	16.9	0	-2.4	-1.2	-1.25
20 Day Aging 160°C						
Tensile strength (psi)	3921	3274	3201	3786	3402	3570
Retained strength (%)	98.4	89.1	96.1	99.7	98.1	99.1
Elongation at break (%)	9.9	1.87	2.557	82.4	4.779	44.9
Retained elongation (%)	30.8	9.8	1.5	20.1	1.7	16.4
Weight loss (%)	29.5	32.3	0	-2.4	-1.2	-1.25
30 Day Aging 160°C	FAIL	FAIL				
Tensile strength (psi)			1076	3962	1454	1981
Retained strength (%)			32.31	104.3	41.9	54.97
Elongation at break (%)			0.5861	4.413	0.8279	0.9449
Retained elongation (%)			0.35	1.07	0.33	0.34
Weight loss (%)			0.375	1.1	1.34	0.25

[0071] The data show that impact-modified polypropylene-g-styrene compositions containing an inorganic filler and a combination of a hindered phenol compound and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

Example 5

[0072] This example demonstrates the effect on heat aging when a combination of a hindered phenol compound and a zinc salt of a mercapto compound are incorporated into an impact-modified formulation containing 35% of a talc filler and a graft copolymer comprising a propylene homopolymer backbone, onto which styrene was graft polymerized.

[0073] The propylene homopolymer used as the backbone polymer was the same as in Example 4.

[0074] The graft copolymer was prepared as described in Example 1 except that 85 parts of styrene were added per hundred parts of polypropylene and the monomer feed rate was 1 pph/min.

[0075] The graft copolymer was then blended with BMWD PP 2, which was described in Example 4. 35% Jetfil 625C talc having a particle size distribution of >2 μm, commercially available from Luzenac America, was added to both samples. A heterophasic polyolefin comprising 40% propylene homopolymer matrix and 60% ethylene/propylene copolymer having an ethylene content of 60% (Heterophasic polyolefin 1) was also added.

[0076] Epon 1002F bisphenol A/epichlorohydrin resin, commercially available from Shell Oil Company, was added to prevent the stabilizers from being complexed in the mineral portion of the formulation, rendering them unable to stabilize the polymer components. The stabilizer package used was 0.065% calcium stearate, 0.1625% Irganox B-225 phenolic antioxidant, and 1.4% ZMTI zinc salt of 2- mercaptobenzimidazole, all percentages being by weight, based on the total weight of the composition.

[0077] The samples were compounded and extruded as described in Example 4. The compounded samples were molded into test bars as described in Example 2. The results of the property evaluations are given in Table 5.

Table 5		
Sample	**Control**	**1**
Talc (%)	34.3725	34.3625
BMWD PP 2 (%)	14.18	13.78
PP-g-S (%)	20.77	20.27
Het. polyolefin 1 (%)	29.95	29.46
Irganox B225 (%)	0.1625	0.1625
Calcium stearate (%)	0.065	0.065
Epon 1002F (%)	0.5	0.5
ZMTI (%))	-	1.4
Physical Properties		
0 Hour Control		
Tensile strength (psi)	4214	4133
Elongation at break (%)	8.78	15.71
Weight (g)	2.43	2.45
5 Day Aging 160°C		
Tensile strength (psi)	4015	4139
Retained strength (%)	95.3	100.15
Elongation at break (%)	6.4	10.27
Retained elongation (%)	72.9	65.37
Weight loss (%)	0.1	0.408
10 Day Aging 160°C		
Tensile strength (psi)	4044	4151
Retained strength (%)	96.0	100.44
Elongation at break (%)	4.13	10
Retained elongation (%)	47.0	63.65
Weight loss (%)	6.7	0.408
20 Day Aging 160°C		

continuation of table 5

Tensile strength (psi)	3182	3841
Retained strength (%)	75.5	92.93
Elongation at break (%)	1.33	4.214
Retained elongation (%)	15.1	26.82
Weight loss (%)	17.4	0.408
30 Day Aging 160°C	FAIL	
Tensile strength (psi)		2341
Retained strength (%)		56.64
Elongation at break (%)		1.15
Retained elongation (%)		7.32
Weight loss (%)		6.12

[0078] The data show that a talc-filled, impact-modified polypropylene-g-styrene composition containing a combination of a hindered phenol compound and the zinc salt of 2-mercaptobenzimidazole exhibits improved heat aging properties compared to the composition without the zinc salt.

Example 6

[0079] This example demonstrates the effect on heat aging when a combination of a hindered phenol compound and a zinc salt of a mercapto compound are incorporated into an impact-modified formulation containing a graft copolymer comprising a propylene homopolymer backbone, onto which methyl methacrylate-co-methyl acrylate was graft polymerized (PP-g-MMA).

[0080] The propylene homopolymer used as the backbone polymer was the same as in Example 4.

[0081] The monomers were grafted onto the polypropylene backbone at a grafting temperature of 115°C using the previously described peroxide-initiated graft polymerization process. Methyl methacrylate (91.4 parts per hundred parts of polypropylene) and 3.6 pph methyl acrylate were added. Lupersol PMS 50% t-butylperoxy-2-ethyl hexanoate in mineral spirits, commercially available from Elf Atochem, was used as the peroxide initiator. The monomer was fed at 0.9 pph/min. The reaction conditions were maintained at 115°C for 30 minutes after completion of monomer and peroxide addition. The temperature was then raised to 140°C for two hours under a nitrogen purge.

[0082] The graft copolymer was blended with BMWD PP 2, which was described in Example 4. The impact modifier used in Table 6 was Engage 8150 ethylene/octene-1 copolymer having a comonomer content of 25% and is commercially available from DuPont-Dow Elastomers.

[0083] The stabilizer package used was 0.1% calcium stearate, 0.25% Irganox B-215 antioxidant, and 1.96% of either Zetax zinc 2-mercaptobenzothiazole or ZMTI zinc 2-mecaptobenzimiazole, all percentages being by weight, based on the total weight of the composition. Irganox B-215 phenolic antioxidant is a mixture of 1 part Irganox 1010 antioxidant and 2 parts Irgafos 168 stabilizer and is commercially available from CIBA Specialty Chemicals Corporation.

[0084] The samples were compounded and extruded on a 34 mm Leistritz extruder at a barrel temperature of 230°C, a screw speed of 350 rpm, and a throughput rate of 50 lb/hr. The compounded samples were molded into test bars as described in Example 2. The results of the property evaluations are given in Table 6.

Table 6			
Sample	**Control.**	**1**	**2**
PP-g-MMA PP (%)	40.1	40.1	40.1
BMWD PP 2 (%)	44.55	42.59	42.59
Engage 8150 (%)	15	15	15
Irganox B215 (%)	0.25	0.25	0.25
Calcium stearate (%)	0.1	0.1	0.1
Zetax (%)	-	1.96	-
ZMTI (%)	-	-	1.96
0 Hour Control			
Tensile strength, yield (psi)	4820	4740	4693
Elongation @ yield (%)	4.19	3.4	4.19
Weight per 'S' bar (g)	1.921	1.95	1.94
5 Day Aging, 160°C			
Tensile strength, yield (psi)	4849	4582	4463
Elongation @ yield (%)	22.8	3.1	2.84
Weight per 'S' bar (g)	1.9	1.936	1.913
Weight loss (%)	1.1	0.7	1.4
10 Day Aging, 160°C			
Tensile strength, yield (psi)	77.57	4326	4424
Elongation @ yield (%)	0.307	2.76	2.92
Weight per 'S' bar (g)	1.65	1.925	1.915
Weight loss (%)	14.1	1.3	1.3
17 Day Aging, 160°C	FAIL		
Tensile strength, yield (psi)		3073	3009
Elongation @ yield (%)		1.55	2.08
Weight per 'S' bar (g)		1.9	1.89
Weight loss (%)		2.6	2.6

continuation of table 6

24 Day Aging, 160°C		FAIL	
Tensile strength, yield (psi)			240.5
Elongation @ yield (%)			0.696
Weight per 'S' bar (g)			1.766
Weight loss (%)			9
30 Day Aging, 160°C			FAIL
Tensile strength, yield (psi)			
Elongation @ yield (%)			
Weight per 'S' bar (g)			
Weight loss (%)			

[0085] The data show that impact-modified polypropylene-g-methyl methacrylate compositions containing a combination of hindered phenol compound and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

Example 7

[0086] This example demonstrates the effect on heat aging when a combination of a hindered phenol compound and a zinc salt of a mercapto compound are incorporated into an impact-modified composition containing a graft copolymer comprising a propylene homopolymer backbone, onto which styrene, α-methylstyrene, and maleic arthydride were graft polymerized (PP-g-S/MA).
[0087] The propylene homopolymer used as the polymer backbone was the same as in Example 4.
[0088] The monomers were grafted onto the polypropylene backbone at a grafting temperature of 90°C using the previously described peroxide-initiated graft polymerization process. Alpha-methylstyrene (44% of the total weight of monomers), styrene (19.6%), and maleic anhydride (36.4%) were added at a total monomer add level of 95 parts of monomer per hundred parts of polypropylene. Lupersol PMS 50% t-butylperoxy-2-ethyl hexanoate in mineral spirits, commercially available from Elf Atochem, was used as the peroxide initiator. The monomer was fed at 0.75 pph/min. A monomer to initiator molar ratio of 100 was used. The reaction conditions were maintained at 90°C for 30 minutes after completion of monomer and peroxide addition. The temperature was then raised to 140°C for 3 hours under a nitrogen purge.
[0089] The graft copolymer was blended with BMWD PP 2, which was described in Example 4, and Engage 8150 ethylene/octene-1 copolymer rubber as an impact modifier.
[0090] The stabilizer package used was 0.25% Irganox B-215 phenolic antioxidant, 0.1% calcium stearate, and 1.96% of either Zetax zinc 2-mercaptobenzothiazole or ZMTI zinc 2-mercaptobenzimidazole, all percentages being by weight, based on the total weight of the composition.
[0091] The samples were compounded and extruded as described in Example 6, except that the barrel temperature was 240°C. The compounded samples were dried at 80°C for at least 4 hours prior to molding to remove surface moisture. The samples were molded into test bars as described in Example 2. The results of the property evaluations are given in Table 7.

Table 7			
Sample	**Control**	**1**	**2**
PP-g-S/MA (%)	40.1	40.1	40.1
BMWP PP 2 (%)	44.55	42.59	42.59
Engage 8150 (%)	15	15	15
Irganox B215 (%)	0.25	0.25	0.25
Calcium stearate (%)	0.1	0.1	0.1
Zetax (%)	-	1.96	-
ZMTI (%)	-	-	1.96
0 Hour Control			
Tensile strength, yield (psi)	4561	4450	4646
Elongation @ yield (%)	3.97	3.75	3.88
Weight per 'S' bar (g)	1.932	1.939	1.937
3 Day Aging, 160°C			
Tensile strength, yield (psi)	4399	4315	4292
Elongation @ yield (%)	16	3.49	5.98
Weight per 'S' bar (g)	1.939	1.914	1.943
Weight loss (%)	+0.4	1.3	+0.3
10 Day Aging, 160°C			
Tensile strength, yield (psi)	1896	4239	4295
Elongation @ yield (%)	1.2	3.96	5.96
Weight per 'S' bar (g)	1.89	1.93	1.92
Weight loss (%)	2.2	0.5	0.8
17 Day Aging, 160°C	FAIL		
Tensile strength, yield (psi)		1568	3789

continuation of table 7

Elongation @ yield (%)		0.895	2.16
Weight per 'S' bar (g)		1.92	1.91
Weight loss (%)		1	1.4
24 Day Aging, 160°C		FAIL	
Tensile strength, yield (psi)			3604
Elongation @ yield (%)			1.55
Weight per 'S' bar (g)			1.915
Weight loss (%)			1.2
30 Day Aging, 160°C			FAIL
Tensile strength, yield (psi)			
Elongation @ yield (%)			
Weight per 'S' bar (g)			
Weight loss (%)			

[0092] The data show that impact-modified polypropylene-g-α-methylstyrene/styrene/maleic anhydride compositions containing a combination of a hindered phenol compound and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

Example 8

[0093] This example demonstrates the effect on heat aging when a combination of a hindered phenol compound and a zinc salt of a mercapto compound are incorporated into an impact-modified composition containing a graft copolymer comprising a propylene homopolymer backbone, onto which styrene was graft polymerized (PP-g-S). The compositions contain either talc or $CaCO_3$ as a filler.

[0094] The propylene homopolymer used as the polymer backbone was the same as in Example 4.

[0095] The graft copolymer was prepared as described in Example 1 except that 85 parts of styrene per hundred parts of polypropylene were added and the monomer feed rate was 1 pph/min.

[0096] The graft copolymer was bended with BMWD PP 2, which was described in Example 4, and heterophasic polyolefin 1, which was described in Example 5.

[0097] The $CaCO_3$ was described in Example 4. The talc was described in Example 5. Epon 1002F bisphenol A/epichlorohydrin resin was added along with a stabilizer package that included 0.13% Irganox B215 phenolic anitoxidant, and 1.3% ZMTI zinc salt of 2-mercaptobenzimidazole, all percentages being by weight, based on the total weight of the composition.

[0098] The samples were compounded and extruded as described in Example 6. The compounded samples were molded into test bars as described in Example 2. The results of the property evaluations are given in Table 8.

Table 8

Sample	C ntrol 1	Control 2	1	2
$CaCO_3$ (%)	35	-	35	-
Talc (%)	-	34.75	-	34.75
PP-g-S (%)	20.9	20.9	20.9	20.9
BMWD PP 2 (%)	23.47	23.47	22.17	22.17
Het. polyolefin 1 (%)	20.5	20.5	20.5	20.5
Epon 1002F (%)	-	0.25	-	0.25
Irganox B215 (%)	0.13	0.13	0.13	0.13
ZMTI (%)	-	-	1.3	1.3
0 Hour Control				
Tensile strength, yield (psi)	3345	4998	3359	4948
Elongation @ yield (%)	2.01	1.99	1.8	2.24
Weight per 'S' bar (g)	2.369	2.395	2.432	2.429
3 Day Aging, 160°C				
Tensile Strength, yield (psi)	3430	3552	3420	4878
Elongation @ yield (%)	1.88	1.27	1.88	1.85
Weight per 'S' bar (g)	2.375	2.364	2.432	2.428
Weight loss (%)	0.9	1.7	0	0.05
10 Day Aging, 160°C				
Tensile strength, yield (psi)	661.1	3915	3290	4321
Elongation @ yield (%)	0.62	0.938	1.65	1.59
Weight per 'S' bar (g)	2.14	2.24	2.42	2.43
Weight loss (%)	10.7	6.5	0.5	0
17 Day Aging, 160°C	**FAIL**	**FAIL**	**FAIL**	**FAIL**
Tensile strength, yield (psi)				
Elongation @ yield (%)				
Weight per 'S' bar (g)				
Weight loss (%)				

[0099] The data show that impact-modified polypropylene-g-styrene compositions containing a mineral filler and a combination of a hindered phenol compound and a zinc salt of a mercapto compound exhibit improved heat aging properties compared to compositions without the zinc salt.

[0100] Other features, advantages and embodiments of the invention disclosed herein will be readily apparent to those exercising ordinary skill after reading the foregoing disclosures. In this regard, while specific embodiments of the invention have been described in considerable detail, variations and modifications of these embodiments can be effected without departing from the spirit and scope of the invention as described and claimed.

Claims

1. A composition comprising:

   (1) a graft copolymer comprising a backbone of a propylene polymer material having graft polymerized thereto polymerized monomers selected from the group consisting of

   (a) vinyl-substituted aromatic compounds,
   (b) unsaturated aliphatic acids or esters thereof,
   (c) anhydrides of unsaturated aliphatic dicarboxylic acids, and
   (d) mixtures thereof;

   (2) about 0.05% to about 0.5% of a sterically hindered phenol compound, based on the total weight of the composition, and
   (3) about 0.5% to about 5.0% of zinc 2-mercaptobenzothiazole, zinc 2-mercaptotoluimidazole or zinc 2-mercaptobenzimidazole, based on the total weight of the composition.

2. The composition of claim 1 wherein the propylene polymer material is selected from the group consisting of:

   (a) a crystalline homopolymer of propylene having an isotactic index greater than 80;
   (b) a crystalline copolymer of propylene and an olefin selected from the group consisting of ethylene and C_4-C_{10} α-olefins, provided that when the olefin is ethylene, the maximum polymerized ethylene content is 10% by weight, and when the olefin is a C_4-C_{10} α-olefin, the maximum polymerized content thereof is 20% by weight, the copolymer having an isotactic index greater than 85;
   (c) a crystalline terpolymer of propylene and two olefins selected from the group consisting of ethylene and C_4-C_8 α-olefins, provided that the maximum polymerized C_4-C_8 α-olefin content is 20% by weight, and, when ethylene is one of the olefins, the maximum polymerized ethylene content is 5% by weight, the terpolymer having an isotactic index greater than 85;
   (d) an olefin polymer composition comprising:

   (i) about 10% to about 50% by weight of a propylene homopolymer having an isotactic index of about 80% to about 99%, or a copolymer selected from the group consisting of (a) a copolymer of propylene and ethylene, (b) propylene, ethylene and a CH_2=CHR alpha-olefin, where R is a 2-8 C straight or branched alkyl group, and (c) propylene and an alpha-olefin as defined above in (i)(b), wherein the copolymer contains about 85% to about 99% propylene and has an isotactic index greater than 80% to about 98%,
   (ii) about 3% to about 20% of a semi-crystalline, essentially linear copolymer having a crystallinity of about 20% to about 60% by differential scanning calorimetry (DSC), wherein the copolymer is selected from the group consisting of (a) ethylene and propylene containing over 50% ethylene; (b) ethylene, propylene, and an alpha-olefin as defined above in (i)(b), containing about 1% to about 10% of the alpha-olefin and over 50% up to 98%, preferably about 80% to about 95%, of both ethylene and alpha-olefin; and (c) ethylene and an alpha-olefin as defined in (i)(b), containing over 50% up to 98% of the alpha-olefin, which copolymer is insoluble in xylene at room or ambient temperature, and
   (iii) about 40% to about 80% of a copolymer selected from the group consisting of a copolymer of (a) ethylene and propylene wherein the copolymer contains from 20% to less than 40% ethylene, (b) ethylene, propylene, and an alpha-olefin as defined in (i)(b), wherein the alpha-olefin is present in an amount of about 1% to about 10%, and the amount of ethylene and alpha-olefin present is from 20% to less than 40%, and (c) ethylene and an alpha-olefin as defined in (i)(b), containing from 20% to less than 40% of the alpha-olefin, and optionally containing about 0.5% to about 10% of a diene, the copolymer (iii) being soluble in xylene at ambient temperature, and having an intrinsic viscosity of about 1.5 to about 4.0 dl/g, wherein the total amount of ethylene units or the alpha-olefin units in the olefin polymer composition or of ethylene and the alpha-olefin units when both are present in the olefin polymer composition is about 15% to about 35%,

   wherein the total amount of (ii) and (iii), based on the total olefin polymer composition is about 65% to about 80%; the weight ratio of (ii)/(iii) is less than 4.0; the total content of ethylene or 4-8 C alpha-olefin or combination thereof in (ii) + (iii) is less than 50%, and the composition is prepared by polymerization in at least two stages and has a flexural modulus of less than 150 MPa; and
   (e) a thermoplastic olefin comprising:

(i) about 10% to about 60% of a crystalline propylene homopolymer having an isotactic index greater than 80, or a crystalline copolymer selected from the group consisting of (a) a copolymer of ethylene and propylene, (b) a terpolymer of ethylene, propylene, and a C_4-C_8 α-olefin, and (c) a copolymer of ethylene and a C_4-C_8 α-olefin, the copolymer having a propylene content greater than 85% and an isotactic index of greater than 85;

(ii) about 20% to about 60% of an amorphous copolymer selected from the group consisting of (a) a copolymer of ethylene and propylene, (b) a terpolymer of ethylene, propylene, and a C_4-C_8 α-olefin, and (c) a copolymer of ethylene and a C_4-C_8 α-olefin, the copolymer optionally containing about 0.5% to about 10% of a diene and containing less than 70% ethylene and being soluble in xylene at ambient temperature; and

(iii) about 3% to about 40% of a copolymer of ethylene and propylene or a C_4-C_8 α-olefin that is insoluble in xylene at ambient temperature,

wherein the composition has a flexural modulus of greater than 150 but less than 1200 MPa.

3. The composition of claim 1 wherein the monomer is styrene.

4. The composition of claim 1 wherein the monomers are styrene, α-methylstyrene, and maleic anhydride.

5. The composition of claim 1 wherein the monomers are methyl methacrylate and methyl acrylate.

6. The composition of claim 1 that additionally comprises about 2% to about 30%, based on the total weight of the composition, of a rubber component selected from one or more of the group consisting of (a) an olefin copolymer rubber, (2) a monoalkenyl aromatic hydrocarbon-conjugated diene block copolymer, and (c) a core-shell rubber.

7. The composition of claim 1 that additionally comprises about 5% to about 90%, based on the total weight of the composition, of a broad molecular weight distribution propylene polymer material having a M_w/M_n of about 5 to about 60 and a melt flow rate of about 0.5 to about 50 g/10 min..

8. The composition of claim 1 that additionally comprises about 20% to about 35% of an inorganic filler selected from the group consisting of (a) calcium carbonate and (b) talc.

9. The composition of claim 1 that additionally comprises about 20% to about 50% of glass fibers.

10. A process for improving the heat aging of a graft copolymer, the process comprising mixing a graft copolymer comprising a backbone of a propylene polymer material having graft polymerized thereto polymerized monomers selected from the group consisting of:

(a) vinyl-substituted aromatic compounds,
(b) unsaturated aliphatic carboxylic acids or esters thereof,
(c) anhydrides of unsaturated aliphatic dicarboxylic acids, and
(d) mixtures thereof, with a combination of (1) about 0.05% to about 0.5% of a sterically hindered phenol compound and (2) about 0.5% to about 5.0% of zinc 2-mercaptobenzothiazole, zinc 2-mercaptotoluimidazole or zinc 2-mercaptobenzimiazole, based on the total weight of the composition.

11. The process of claim 10 wherein the propylene polymer material is selected from the group consisting of:

(a) a crystalline homopolymer of propylene having an isotactic index greater than 80;
(b) a crystalline copolymer of propylene and an olefin selected from the group consisting of ethylene and C_4-C_{10} α-olefins, provided that when the olefin is ethylene, the maximum polymerized ethylene content is 10% by weight, and when the olefin is a C_4-C_{10} α-olefin, the maximum polymerized content thereof is 20% by weight, the copolymer having an isotactic index greater than 85;
(c) a crystalline terpolymer of propylene and two olefins selected from the group consisting of ethylene and C_4-C_8 α-olefins, provided that the maximum polymerized C_4-C_8 α-olefin content is 20% by weight, and, when ethylene is one of the olefins, the maximum polymerized ethylene content is 5% by weight, the terpolymer having an isotactic index greater than 85;
(d) an olefin polymer composition comprising:

(i) about 10% to about 50% by weight of a propylene homopolymer having an isotactic index of about 80%

to about 99%, or a copolymer selected from the group consisting of (a) a copolymer of propylene and ethylene, (b) propylene, ethylene and a CH_2=CHR alpha-olefin, where R is a 2-8 C straight or branched alkyl group, and (c) propylene and an alpha-olefin as defined above in (i)(b), wherein the copolymer contains about 85% to about 99% propylene and has an isotactic index greater than 80% to about 98%,

(ii) about 3% to about 20% of a semi-crystalline, essentially linear copolymer having a crystallinity of about 20% to about 60% by differential scanning calorimetry (DSC), wherein the copolymer is selected from the group consisting of (a) ethylene and propylene containing over 50% ethylene; (b) ethylene, propylene, and an alpha-olefin as defined above in (i)(b), containing about 1% to about 10% of the alpha-olefin and over 50% up to 98% of both ethylene and alpha-olefin; and (c) ethylene and an alpha-olefin as defined in (i)(b), containing over 50% up to 98% of the alpha-olefin, which copolymer is insoluble in xylene at room or ambient temperature, and

(iii) about 40% to about 80% of a copolymer selected from the group consisting of a copolymer of (a) ethylene and propylene wherein the copolymer contains from 20% to less than 40% ethylene, (b) ethylene, propylene, and an alpha-olefin as defined in (i)(b), wherein the alpha-olefin is present in an amount of about 1% to about 10% and the amount of ethylene and alpha-olefin present is from 20% to less than 40%, and (c) ethylene and an alpha-olefin as defined in (i)(b), containing from 20% to less than 40% of the alpha-olefin, and optionally containing about 0.5% to about 10% of a diene, the copolymer (iii) being soluble in xylene at ambient temperature, and having an intrinsic viscosity of about 1.5 to about 4.0 dl/g, wherein the total amount of ethylene units or the alpha-olefin units in the olefin polymer composition or of ethylene and the alpha-olefin units when both are present in the olefin polymer composition is about 15% to about 35%,

wherein the total amount of (ii) and (iii), based on the total olefin polymer composition is about 65% to about 80%; the weight ratio of (ii)/(iii) is less than 0.4; the total content of ethylene or 4-8 C alpha-olefin or combination thereof in (ii) + (iii) is less than 50%, ad the composition is prepared by polymerization in at least two stages and has a flexural modulus of less than 150 MPa; and

(e) a thermoplastic olefin comprising:

(i) about 10% to about 60% of a crystalline propylene homopolymer having an isotactic index greater than 80, or a crystalline copolymer selected from the group consisting of (a) a copolymer of ethylene and propylene, (b) a terpolymer of ethylene, propylene, and a C_4-C_8 α-olefin, and (c) a copolymer of ethylene and a C_4-C_8 α-olefin, the copolymer having a propylene content greater than 85% and an isotactic index of greater than 85;

(ii) about 20% to about 60% of an amorphous copolymer selected from the group consisting of (a) a copolymer of ethylene and propylene, (b) a terpolymer of ethylene, propylene, and a C_4-C_8 α-olefin, and (c) a copolymer of ethylene and a C_4-C_8 α-olefin, the copolymer optionally containing about 0.5% to about 10% of a diene and containing less than 70% ethylene and being soluble in xylene at ambient temperature; and

(iii) about 3% to about 40% of a copolymer of ethylene and propylene or a C_4-C_3 α-olefin that is insoluble in xylene at ambient temperature,

wherein the composition has a flexural modulus of greater than 150 but less than 1200 MPa.

12. The process of claim 10 wherein the monomer is styrene.

13. The process of claim 10 wherein the monomers are styrene, α-methylstyrene, and maleic anhydride.

14. The process of claim 10 wherein the monomers are methyl methacrylate and methyl acrylate.